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Financing of Activities Increasing the Energy Efficiency of Residential Buildings in Poland

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Abstract:

Purpose: *The aim of the study is to review and assess the sources and effects of financing for investments in the energy modernisation of buildings as an element shaping a low-carbon economy in Poland.*
Design/methodology/approach: *An answer was sought to the question of why owners of single-family houses remain marginalised in supporting the financing of energy modernisation projects. The financial tools were reviewed in the context of the effects achieved, e.g., reduction of energy poverty of households, reduction of low emissions, counteracting contradictory incentives.*
Findings: *Single-family house owners constitute the vast majority (80%) in the ownership structure of dwellings in Poland. However, they are not a homogeneous group. A dispersed group of owners is a barrier to systemic access with an offer of financial support.*
Practical Implications: *When developing a modernisation programme for single-family buildings, the key issue is to precisely identify the programme's addressees. The legal and financial instruments and the institutional structure should be differentiated for each target sub-group. For wealthier households, the offer of tax benefits should be developed. The poorest households should be protected above all from energy poverty, especially in view of the rise in energy prices observed in recent weeks.*
Originality/Value: *The article systematizes information on the impact of construction on climate change and the development of energy policy.*

Keywords: *Energy efficiency, residential buildings, energy consumption, financing*.

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1. Introduction

The construction and housing sector is responsible for the highest energy consumption in the EU. According to data from the European Commission, it absorbs almost 40% of total final energy consumption, thus accounting for 36% of European greenhouse gas emissions (GHG) and 40% of global emissions (In focus on energy… 2020; Lin and Liu, 2015; Huo *et al.,* 2019). At the same time, due to accelerated urbanisation and the resulting demand for energy consumption, greenhouse gas emissions in the construction sector have more than doubled globally since 1970 (Building Market…, 2019). In some regions of the world (e.g. China), a tripling has been recorded (Huo *et al.,* 2021).

The high potential for energy renovation of building stocks can therefore play an important role in reducing the negative impact on the natural environment and is perceived as a key action towards carbon neutrality (He *et al.,* 2019). We spend over 90% of our time indoors, i.e., in the office or at home. The energy used in residential buildings - households constitutes a significant percentage of the total energy consumption in a given country (in Poland it is approx. 25%). This percentage depends largely on the degree of electrification, the level of urbanization, the building area per capita, the prevailing climate, as well as national and local policies promoting energy efficiency. The energy efficiency of a building is understood as the degree to which the energy consumption per square meter of the building floor area corresponds to the established benchmarks for energy consumption for that specific type of building under certain climatic conditions.

One of the assumptions of the European Green Deal is to prioritize energy efficiency, improve the energy performance of buildings and develop an energy sector based mainly on renewable sources. The implementation of these goals will be supported by the multiannual financial framework of the European Union (funds from the EU budget) for 2021-2027, in which as many as a quarter of funds will support directly or indirectly the achievement of climate goals, including improvement of the energy efficiency of buildings.

2. Research Methodology

Energy efficiency is one of the areas on which there has been consensus in Poland for a long time. All successive governments and leading political parties agree that improving the standards of energy consumption in industrial installations, public buildings and homes, as well as household appliances, brings tangible economic and environmental benefits. In 1998, Poland was one of the first European countries to launch the first public financial support program for thermal modernization of buildings through the Thermomodernization and Renovation Fund.

Unfortunately, government documents and programmes have not included the single-family housing sector in their financial support, despite the fact that 91% of

residential buildings are single-family houses, in which more than half of the population lives. At the same time, single-family dwellings are the biggest source of air pollution (so-called “low emissions”) and 40% of them do not have any insulation (Zaborowski and Walczak, 2017).

The vast majority of funds was directed to institutional beneficiaries (housing cooperatives, housing communities, social housing associations, municipalities). This raises the question why such a large group of single-family houses owners has been marginalised in access to public financing? Is the dispersed group of owners a barrier to systemic outreach with financial support offers (almost 80% of flats in Poland are owned by natural persons)? Are the existing instruments and forms of support sufficient? The article has an analytical and review character. Therefore, the aim of this research is to review and evaluate the sources and effects of financing investments in energy renovation of residential buildings as an element shaping a low-carbon economy in Poland.

A detailed description of financing instruments for energy efficiency projects was provided by Rezessy and Bertoldi (2010), dividing them into the following groups: debt financing, equity financing, subordinated debt financing (mezzanine finance), project financing, Other financing mechanisms: developing energy efficiency financial products and creating demand for energy efficiency finance and supplementary mechanisms: public finance mechanisms, policies and programs. Bertoldi *et al.* (2021) additionally systematized them according to the level of innovation, dividing them into three groups:

a)Traditional and well-established (grants and subsidies, tax incentives, loans),
b)Tested and growing (energy efficiency obligations, energy services companies (ESCO) and energy performance contracting, energy services agreement),
c)New and innovative (on-bill finance, property assessed clean energy (PACE) financing, energy efficient mortgages, energy efficiency feed in tariffs, incremental property taxation, one-stop shops, crowdfunding).

The article focuses on public financing, which at the current stage of development and energy transformation of Poland is the main source of support for investments in the energy renovation of buildings.

Energy renovation is understood as thermal modernization of a building, replacement of a heat source with low-emission ones and installation of renewable energy sources. The detailed rules of energy renovation resulting from the legal regulations of the European Union's climate and energy policy are presented. Then, through a detailed characterization of the building stock, renovation needs were presented.

The study is based on secondary data obtained from public institutions (Ministry of Funds and Regional Policy, Ministry of Development and Technology, Central

Statistical Office, Central Office of Geodesy and Cartography, National Fund for Environmental Protection and Water Management, Long-term Renewal Strategy - Supporting the Renewal of the National Building Stock) and studies by private institutions (WiseEuropa - Foundation of the Warsaw Institute for Economic and European Studies and Buildings Performance Institute Europe).

The financial tools were reviewed in the context of the effects achieved, e.g. reduction of energy poverty of households, reduction of low emissions, counteracting contradictory incentives. Conflicting incentives - diverging interests in energy efficiency occur when the end-user is responsible for the energy bills but cannot choose the technology needed to improve the energy efficiency of the premises, and thus has limited ability to influence the reduction of energy bills, e.g., in a landlord-tenant relationship (Castellazzi *et al.,* 2017).

3. Background and Literature Review

3.1 Fundamentals of the Climate and Energy Policy of the European Union

Global and EU climate policy sets the directions of development for many other policies, especially energy. The EU adopted and implemented the concept of climate policy in 1993 by ratifying the Climate Convention, and in Art. 191 of the Treaty on the Functioning of the EU made a direct reference to the obligation "to promote measures at international level to deal with regional or worldwide environmental problems, in particular combating climate change." (A roadmap…,2011; Fedoskina, 2016). Stopping the progressive climate change with the consequences for the environment, economy and societies will be possible under the condition of transition to a low-carbon economy.

The key elements on which the formation of a low-emission economy is based are the reduction of emissions, especially carbon dioxide, reasonable resource management, also in a circular economy, and energy efficiency. Efficient use of energy means the rational and sustainable use of both energy itself and the energy resources used to generate it. Improving energy efficiency is sometimes referred to as the "sixth fuel", because it limits the increase in the demand for fuels and energy.

Thus, it contributes to increasing energy security by reducing dependence on imports, and also reduces the negative impact of energy on the environment and human health by reducing greenhouse gas emissions (Information on results of the inspection... 2020). Transition to a low-emission economy is a process involving changes on three interrelated levels: management conditions (development of energy-saving solutions and renewable energy sources (RES) technologies, promotion of material-saving production and industrial processes), environmental protection and energy security. Environmental education - professional and social, as well as shaping appropriate consumer attitudes are also important. The above-mentioned elements are at the same time a framework for ensuring the economic,

energy and ecological security of the country and shaping the framework for sustainable and lasting development (Daly, 2007; Szyja, 2020).

Rifkin (2011) predicts that the third industrial revolution involves much more than just a change in the energy regime. The new system will also entail completely new business models. Widely available types of renewable energies enable the emergence of thousands of dispersed companies and business partnerships operating within collective grids that function more like ecosystems than economic markets.

The author emphasizes that a civilization based on fossil fuels is likely to collapse around 2028. Brigde *et al.* (2012), on the other hand, study the energy transformation as a geographical process, including the reconfiguration of current patterns and the scale of economic and social activity. They define this phenomenon as a "new energy paradigm".More than 75% of EU greenhouse gas emissions come from the production and use of energy. Decarbonising the EU's energy system is therefore key to meeting the climate goals and the EU's long-term strategy to become carbon neutral by 2050 (In focus on energy…, 2020).

The two key elements of the package relating to the reduction of greenhouse gas emissions are:

- Directive 2009/29 / EC of the European Parliament and of the Council of 23 April 2009 amending Directive 2003/87 / EC in order to improve and extend the Community greenhouse gas emission allowance trading scheme (the so-called EU ETS Directive), (Emission Trading Scheme) which relates directly to the amount of emissions from individual installations.
- Decision 2009/406 / EC of the European Parliament and of the Council of 23 April 2009 on efforts by Member States to reduce greenhouse gas emissions in order to meet the Community's greenhouse gas emission reduction commitments by 2020 (the so-called ESD decision) (Effort Sharing Decision) - concerning the non-ETS area and determined at the level of the European Union Member States.

The introduction of the regulation in 2009 allowed attention to be paid to non-installation emissions, as non-ETS is understood as that part of domestic greenhouse gas emissions that are not covered by the EU ETS. The following sectors are included in the non-ETS emissions: transport, agriculture, waste, industrial emissions outside the ETS, municipal and housing sector with buildings and flats, small emission sources, households, services (Frączyk 2009; Kowalke and Prochowiak, 2014). The volume of non-ETS emissions in Poland is more or less similar to the volume of emissions in the EU ETS, while in the entire European Union the share of non-ETS emissions is approx. 55% of the total emissions (National Centre for Emissions Management, 2018).

In 2014, the European Council adopted Conclusions in which it defined the framework for the European climate and energy policy until 2030 (Conclusions of…, 2021). The conclusions set the EU's emission reduction target to cut domestic greenhouse gas emissions by at least 40% by 2030 compared to 1990 levels. It was agreed that for the achievement of the international target by 2030 in the most cost-effective way, two separate targets should be set for sectors: EU ETS (-43% compared to 2005) and non-ETS (-30% compared to 2005). As was the case in the period 2013-2020, the amount of non-ETS emissions is determined at the level of the European Union Member States.

In the period 2013-2020, matters relating to non-ETS sectors are regulated by the ESD decision, however, due to the upcoming period of 2021-2030, a new regulation succeeding the ESD has been adopted, i.e., Regulation of the European Parliament and of the Council No. 2018/842 (the so-called ESR Regulation). In line with the ESR, Poland is committed to reducing greenhouse gas emissions from non-ETS sectors by 2030 by 7% compared to 2005 levels.

The European Green Deal also focuses on three main objectives for the clean energy transition, which will help reduce greenhouse gas emissions and improve quality of life. These assumptions are: ensuring affordable and secure energy supply in the EU, creating a fully integrated, interconnected and digital EU energy market and prioritizing energy efficiency, improving the energy performance of buildings and developing an energy sector based mainly on renewable sources (European Green Deal, 2021). The newest plan, "Fit for 55", adopted on July 20, 2021, aims to reduce GHG emissions by 55% by 2030 before achieving the complete decarbonation envisaged by the European Green Deal in 2050.

3.2 Energy Efficiency in Construction

We spend over 90% of our time indoors, i.e., in the office or at home. The energy used in buildings (residential and commercial) accounts for a significant percentage of the total energy consumption of a country. This percentage depends largely on the degree of electrification, the level of urbanization, the building area per capita, the prevailing climate, as well as national and local policies promoting energy efficiency.

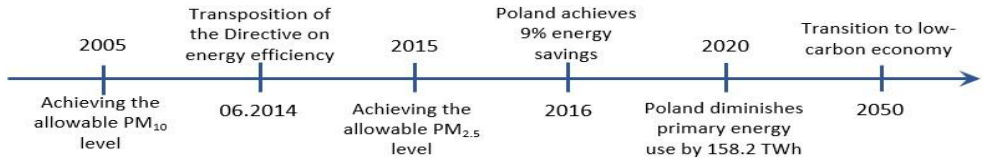
In the European Union countries, it is about 40% (Funding climate…, 2010) with residential buildings responsible for 25% of total consumption (Tsemekidi *et al.,* 2019). Given the long lifetime of buildings, estimates indicate that at least 75% of the EU's current building stock will continue to be used in 2050. Existing buildings therefore represent the greatest challenge and opportunity as at least half of the existing residential and commercial buildings require deep, comprehensive renovation (Urge-Vorsatz *et al.,* 2012; Femenías *et al.,* 2018; Jensen *et al.,* 2018).

The energy efficiency of a building is the degree to which the energy consumption per square meter of floor area of a building corresponds to the established benchmarks for energy consumption for that specific type of building under certain climatic conditions. Building energy benchmarks are values representative of typical building types with which real building performance can be compared.

According to the World Energy Council, the concept of energy efficiency means "lower levels of energy consumption for the same comfort" (World Energy Council, 2004). In the Act of 2016 on energy efficiency (being the implementation of the EPD Directive of 2012 on energy efficiency), it was stated that energy efficiency is the ratio of the obtained value of the utility effect of a given object, technical device or installation, under typical conditions of their use or operation , to the amount of energy consumption by the object, technical device or installation or as a result of the service necessary to achieve this effect (Act of the Energy Efficiency, 2016).

Increasing the energy efficiency of the processes of production, transmission and use of energy is a pillar of a sustainable energy policy. Improving the energy efficiency of buildings is therefore a strategic direction for the development of the entire European Union. As said by the President of the European Council, Herman Van Rompuy: "Energy efficiency is the most impactful measure that governments can take to save energy. Buildings are the sector with the greatest potential for energy efficiency in the EU. The energy efficiency of buildings is not a cost, but an investment with a huge rate of return" (Van Rompuy, 2013). This is reflected in the legislation and activities undertaken by EU and national institutions. The history of introducing directives and achieving successive stages in improving energy efficiency and creating a low-carbon economy is presented in Figure 1.

Figure 1. *Timeline of implementation of objectives related to the legal regulations regarding buildings, resulting from the EU legislation*



Source: *Own work.*

Greater interest in the issues of energy consumption in buildings appeared in individual European Union countries in the 1990s and resulted in the adoption in December 2002 of the EU Directive on the energy performance of buildings (2002/91/EC), the so-called EPBD (Energy Performance Buildings Directive) (Brunsgaard *et al.*, 2013; Economidou *et al.*, 2020). It defined the share of residential and service buildings in the total energy consumption in the European Union. Then, for the first time, this share was set at 40% with a growing perspective.

Consequently, the primary objective of the 1st EPBD was to promote energy-efficient construction and improve the energy performance of buildings. For this purpose, many tools have been introduced, the most important of which is:

- a system of building energy performance certificates;
- energy assessment and certification system for buildings;
- a set of implementing legal acts enabling the effective implementation of the above-mentioned tools.

The energy performance certificate, its comprehensibility, and the way of presenting information about the energy parameters of the building were to play a key role in promoting energy-efficient construction among buyers and users of buildings (Witczak, 2012). Andelkovic *et al.* (2021) indicate, however, significant differences between the theoretical (defined methodologically) and the actual energy consumption. In 2010, the so-called EPBD recast was implemented (II EPBD) (Directive 2010/31/EU), which is the 2010/31/UE Directive. The definition of nearly zero energy building (nZEB) was introduced. It stands for a building with very high energy performance, where a significant proportion of the energy should come from renewable sources.

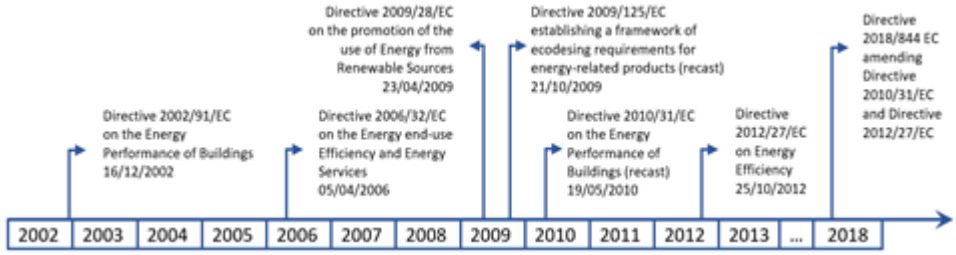
Determining the size of the so-called almost zero is left to the EU Member States, providing a tool in the form of a Delegated Regulation with an optimal total cost. According to the assumptions of the EPBD recast and the said regulation, a building in the nZEB standard is one for which the total costs in the assumed calculation period are the lowest (30 years for residential buildings) (Economidou *et al.*, 2020). According to the procedure of calculating the total cost, legislators in individual EU countries should take into account, in addition to investment costs, all kinds of costs related to the operation of a building and its technical systems (Gatta *et al.*, 2020). Moghaddasi *et al.* (2021) draw attention to the differences in the existing criteria, definitions and calculation methodologies adopted for the classification of buildings in the nZEB standard.

In 2012, Directive 2012/27/EU on energy efficiency (the so-called EED) was introduced to intensify activities in this area. Obliges EU member states to introduce energy efficiency improvement instruments that enable the achievement of the target of 20% savings in primary energy consumption by 2020. In the case of Poland, the primary energy consumption target was set at 1.12PWh. The implementation of this directive into the national order is provided by the Energy Efficiency Act of May 20, 2016. Directive 2018/2002 of December 11, 2018 introduced the energy efficiency improvement target of 32.5% by 2030.

On June 19, 2018, Directive 2018/844 EU was published in the Official Journal of the European Union, amending Directive 2010/31 / EU on the energy performance of buildings and Directive 2012/27/EU on efficiency energy (National Centre…, 2018). This is the third version of the European Parliament directive on improving

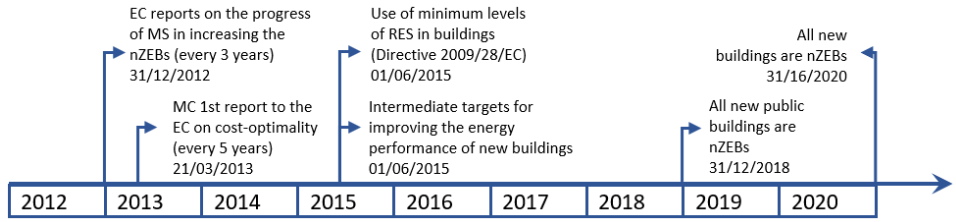
the energy efficiency of buildings (the so-called 3rd EPBD). The new directive entered into force on 9 July 2018. The next stages of the EU regulations being introduced are shown in Figures 2 and 3.

Figure 2. *Key Directives related to buildings*



Source: *Own work based on Principles and benchmarks for nearly Zero-Energy Buildings (2021).*

Figure 3. *Key years for nearly zero energy buildings.*



Source: *Own work based on Principles and benchmarks for nearly Zero-Energy Buildings (2021).*

The latest EPBD III directive introduces the obligation to draw up long-term renovation strategies for all building stocks and the existing stock of residential and non-residential buildings (both public and private), in order to achieve by 2050 their high energy efficiency corresponding to the standard of nearly zero-energy buildings (the so-called nZEB standard according to EPBD 2010/31/EU).

Long-term renovation strategies will be subject to reporting to the European Commission. They must take into account, among others assessment of the current state of building stock, review and assessment of mechanisms promoting and supporting renovation activities for private and public investors, and, which is particularly important from the point of view of our country, assessment of the impact of renovation of buildings on the effects related to, among others, with the improvement of air quality.

The Directive III EPBD reaches its assumptions until 2050, taking into account, in addition to the traditional thermal modernization of buildings, many technological novelties, know-how, which are still in the development and testing phase (Economidou *et al.*, 2020; Witczak, 2021).

Pursuant to the above-mentioned EU regulations, the Act on energy efficiency, the National Energy Efficiency Action Plan for Poland (2017), from January 1, 2022, the Central Emission Register of Buildings will operate.

4. Research Results

4.1 The Stock of Residential Buildings in Poland

The construction and housing sectors play an important role in reducing negative environmental impacts. Therefore, it is very important that investors, designers and contractors use innovative solutions increasing the energy efficiency of buildings and reduce the consumption of raw materials and materials. This may be associated with a departure from known and proven solutions, but currently ineffective.

Reducing the consumption of domestic hot water, electricity or energy necessary to heat the building reduces the extraction and consumption of non-renewable fuels (Parasonis *et al.*, 2012). The use of recycled products reduces the generation of waste. Such activities allow to define construction as sustainable, i.e., at every stage of the investment implementation, taking into account environmental (reducing the consumption of materials, energy, water) and economic (cost rationalization) aspects, ensuring a healthy and safe place to live. Meanwhile, 35% of buildings in the EU are over 50 years old and 75% of the building stock is energy inefficient (The energy performance of buildings…., 2020). The main emitter in most countries of the Old Continent are buildings built before the implementation of the first pan-European standards in the field of greenhouse gas emissions. The Polish construction stock consists of 14.2 million buildings (Table 1).

Table 1. *The structure of buildings in Poland as of January 1, 2020 by type*

Category	Number of buildings, in thous.
multi-family residential buildings	553
single-family residential buildings	5,604
collective accommodation buildings	3.9
public utility buildings	420
production, utility and warehouse buildings	5,116
other non-residential	2,491
Total	14,189

Source: *Own study based on data from Statistics Poland (GUS) and Polish Head Office of Geodesy and Cartography.*

Single-family residential buildings are in the first place in terms of the number (39.4%), which translates into the specificity of the Polish construction industry, with a dispersed ownership structure in this segment. Almost 80% of the housing stock is privately owned, which is one of the highest shares in Europe. The total area of buildings in Poland is 1,562 million m^2. As much as 68% of this area (1,063

million m^2) belongs to the residential sector (58% for single-family buildings, 42% - for multi-family buildings) (Kuczera and Płoszaj- Mazurek, 2021).

The vast majority of single-family buildings are located in rural areas - almost 3.3 million, over 1.7 million in cities. Contrary to the European average, more than 90% of these houses are free-standing (less than 60% in the EU). There are definitely fewer terraced and semi-detached buildings, which undoubtedly has a negative impact, among others on building maintenance costs. The dominance of single-family buildings in relation to multi-apartment buildings does not translate into the location of apartments in the type of building (single-family, multi-family). Out of the total number of 12.9 million apartments, over 7.7 million are located in multi-family buildings, which constitutes almost 60% of all apartments[4].

In Poland, there are about 5.2 million in single-family building apartments. These flats are usually larger in terms of area compared to flats located in multi-family buildings, and are also characterized by a higher population density (per flat, not per unit area). As a result, it turns out that more than half of Poles live in single-family houses - about 19.5 million per 38 million inhabitants, of which almost 6.5 million in cities and over 13 million in the countryside. In percentage terms, almost 90% of rural residents and almost 30% of urban residents live in single-family houses. According to some data, in the last decade the percentage of Poles who decided to live in single-family houses has increased and, as a result, this share increased from 49.5% in 2005 to 53.7% in 2013 (Bank loan product…, 2016).

The Polish residential building sector has one of the worst energy consumption and CO_2 emissions rates. In Europe, CO2 emissions lie in a wide range from 5 kg CO2/ m^2 in Norway to 120 kg CO_2/m^2 in Iceland. With the average emission in Europe at 54 kg $CO2/m^2$, in Poland it exceeds 110 kg CO2/m2 (Economidou, 2011). The high energy demand is mainly evidenced by the construction period, the older the buildings, the higher the energy consumption.

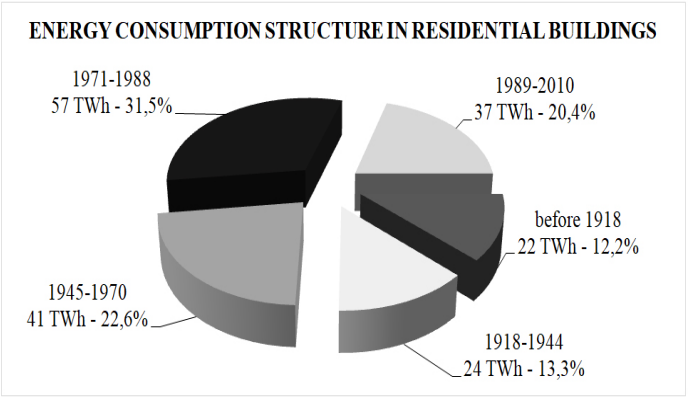
Approximately 70% of residential buildings in Poland were commissioned before 1990, i.e., at a time when, in the conditions of a centrally planned economy, energy prices were low and did not reflect its economic value. The technical solutions used at that time, to a much lesser extent than now, took into account the thermal insulation of buildings, and the appropriate internal temperature was provided by extensive heating systems consuming relatively large amounts of energy (Figure 4).

Buildings constructed in the years 1971-1988 have the highest share in the stock, their share in the age structure is 31.5%. These were the years of intensive development of the construction industry, which, unfortunately, was not associated

[4]*At the end of 2020, the number of apartments in Poland increased to 15 million, but there are no detailed data on their layout. The census of the Central Statistical Office lasted until 30/09/2021, the results of which will probably be published in 2022.*

with high quality standards. In those years, the so-called large-panel in the formula of housing cooperatives. A significant share of buildings from 1971-1988 was at least insulated, because housing cooperatives were one of the first entities to benefit from co-financing thermal modernization investments.

Figure 4. *The structure of energy consumption in residential buildings in Poland by construction period*



Source: *Own study based on Lis (2019).*

However, they remain the group with the highest share in energy consumption by residential buildings in Poland. The median value of the indicator of the annual demand for primary energy in buildings built before the 1990s is two or three times higher than in buildings erected in later periods.

Table 2. *Median value of the indicator of the annual primary energy demand of residential buildings depending on the year of commissioning [kWh / (m^2 / year)]*

	<1994	1994-1998	1999-2008	2009-2013	2014-2016	2017-2018	2019-2020
single-family	263,7	147,9	143,5	126,3	109,1	94,0	89,3
multi-family	258,9	139,0	110,0	142,7	97,5	87,0	84,9

Source: *Own study based on Statistics Poland (GUS) and Polish Head Office of Geodesy and Cartography.*

Along with the tightening technical conditions resulting from EU legislation and the growing awareness of the public, investors pay more and more attention to reducing the energy demand of buildings. This is especially important in the case of single-family housing, which due to technical conditions (lack of common walls, loose development) has a higher energy demand compared to multi-apartment buildings built in the same period. Despite significant progress in reducing the energy consumption of buildings in Poland, there are still opportunities to increase energy efficiency and approach the level of countries with a similar climate zone. And so, in Germany the average final energy consumption in a single-family house decreased

from 246 in 1957, through 176 in 1978, 94 in 1995 to 53 kWh/m^2/year in 2010 (Economidou, 2011; Kauffmann *et al.*, 2010).

According to various analyzes, final energy consumption in new Polish single-family houses is currently approx. 120 to 140 kWh/m^2/year, while houses built before 1967 consume up to 350 kWh/m^2/year (Report on energy condition of buildings in Poland, 2009).

More than half of the population lives in single-family buildings. This is of great importance for reducing the phenomenon of energy poverty. The necessity to include in the long-term strategy of building renovation in alleviating the phenomenon of energy poverty is mentioned, among others, by Recital 12 of Directive III EPBD.

According to the directive, it will be up to the Member States to establish criteria for the impact of improving the energy efficiency of buildings on energy poverty, which means that individual EU countries will have to adopt their official methods and definitions of energy poverty. In 2016, 12.2% of the Polish population was affected by energy poverty. In absolute terms, it meant 4.6 million people in 1.3 million households. 75% of all the energy poor are people living in single-family houses. The vast majority (2/3) of the energy poor are rural residents. In this group, the energy poverty rate is also the highest - as much as 20% of rural residents are energy poor.

This is a consequence of the relatively lower income of rural residents and living in single-family houses of often quite large areas and low energy efficiency. An important aspect is also the frequent lack of access to the heating and gas networks (Sałach and Lewandowski, 2018).

4.2 Public Sources and Tools of Financing for Energy Renovation

The main source of financing for pro-ecological investments, including in the construction sector in Poland, is the National Fund for Environmental Protection and Water Management (hereinafter referred to as "NFEPWM"). The revenues of the NFEPWM mainly come from environmental fees and penalties, operating and license fees, energy sector fees, fees under the Act on the recycling of end-of-life vehicles and the sale of greenhouse gas emission allowances.

Another one is Bank Gospodarstwa Krajowego - National Economy Bank (hereinafter referred to as "NEB"), the state development bank, whose mission is to support the socio-economic development of Poland and the public sector in the performance of its tasks. NEB is the institution responsible for the operational functioning of the Thermomodernization and Renovation Fund (TRF) (Act of 21 November, 2008). Bonuses are paid from the Fund, supported from the state budget, which are part of the loan taken out for thermomodernization or renovation projects.

These loans are granted by commercial banks that concluded an appropriate agreement with BGK. The Subsidy Fund also supports projects involving the renovation or change of use of existing buildings or premises. As a rule, this aid is directed to social housing, intended for the poorest people.

European Regional Development Fund The European Regional Development Fund (hereinafter referred to as "ERDF") aimed at strengthening the economic and social cohesion of the European Union by correcting disproportions between individual regions. The ERDF supports, among others, activities promoting energy efficiency and the use of renewable energy in enterprises, as well as in the public and housing sectors. The ERDF finances, among others, Regional (voivodship) Development Programs, under which priority actions and the resulting support programs are established. ERDF budget allocated to building retrofit projects: approx. EUR 1.7 billion.

The Cohesion Fund (hereinafter referred to as "CF"), the aim of which is to reduce economic and social disparities and to promote sustainable development. Funds from CF are allocated to support: development of trans-European transport networks, projects related to energy, transport, use of renewable energy sources, which are to provide environmental benefits due to the improvement of energy efficiency. CF budget allocated to thermal modernization projects of buildings, EUR 592 million.

The Norwegian Funds - Environment, Energy and Climate Change Program The EEA Financial Mechanism and the Norwegian Financial Mechanism (i.e., the so-called EEA and Norway Grants) are a form of non-returnable foreign aid granted by Iceland, Norway and Liechtenstein to new EU members, including Poland. The resources of the EEA and Norway Grants are distributed among separate programs, each of which covers a different priority area.

Funding for thermal modernization is included in the Environment, Energy and Climate Change Program, which aims to mitigate climate change. or the modernization of individual heat sources. Budget of the entire Program, EUR 164.7 million in the Program funds are intended, inter alia, for the modernization of school buildings in order to bring them to a passive standard, including EUR 140 million from the EEA Financial Mechanism and EUR 24.7 million from the national contribution. Local government units may provide targeted subsidies from the budget. Funds from municipal budgets are allocated, among others, to activities related to environmental protection, low-carbon economy or combating energy poverty.

4.3 Discussion of Research Results

The estimated value of low-emission investments in energy renovation of buildings implemented with the support of public funds in 2014-2019 amounted to EUR 5 billion.

Table 3. *A set of financial tools and activities targeted at selected recipients*

Program name / Period of operation /Funds allocation	Allocation form	Single-family	Multi-family	Public utility	other non-residential	Improving air quality	Counteracting energy poverty	Buildings with the worst characteristics energetycznej	Counteracting contradictory stimuli
The „Clean Air" program; 2018-2029 EUR 22.2 billion	Subsidy loan	x				x	x		
The "Energy-efficient construction" program. Part 1) Reduction of energy consumption in construction; 2019-2023; EUR 355.6 million	Subsidy loan			x	x			x	
The "Clean air in schools" program; 2021-2025	Subsidy ESCO, PPP			x					
Thermomodernization and Renovation Fund; from 1999; EUR 581.3 million	thermomodernization, renovation and compensation bonus,	x	x	x		x	x	x	x
Subsidy Fund; from 2003	subsidy		x				x	x	x
The Operational Program Infrastructure and Environment - OPI & E, sub-measure 1.3.1- Supporting modernization in public buildings; 2014-2020; EUR 431.5 million	subsidy			x					
OPI & E, sub-measure 1.3.2 and 1.7.1 Supporting modernization in residential buildings; 2014-2020; EUR 121.1 million	subsidy		x						
OPI & E, measure 1.2 - promoting energy efficiency and the use of renewable energy sources in enterprises; 2014-2020; EUR 39.9 million	subsidy				x				
Regional Operational Programs; 2014-2020; EUR1,4 billion	subsidy		x	x	x				
Thermomodernization relief; from 2019	tax relief	x							
Low Emission Restriction Programs; from 2015		x					x	x	
The „Stop Smog" program; from 2015	subsidy	x					x	x	

Source: *Own study based on Long-term Strategy for Renovation… (2021); Ministry of Development and Technology, Ministry of Funds and Regional Policy*

Over 75% of the funds (EUR 3.75 billion) were allocated to thermal modernization of buildings, the remaining funds allowed for the replacement of heat sources and installations of renewable energy sources (less than 1/3 of which was allocated to photovoltaic panels) (Ministry of Funds and Regional Policy; Ministry of Development and Technology; Funding climate and energy transition in the EU, 2020; Marszał *et al.,* 2020; Kunikowski 2018). More than half of investments in the energy efficiency of buildings supported by public funds in 2014-2019 were made in public buildings.

Investments in thermal modernization of residential buildings, supported by public policy instruments, amounted to approximately EUR 1.6 billion in 2014-2019. In 2014-2018, the supported projects concerned almost exclusively multi-family buildings, while in 2019 investments in single-family buildings accounted for almost 80% of supported investments in residential buildings. This is due to the thermo-modernization relief introduced in this period and the emergence of the first effects of the "Clean Air" program, being a response to the current lack of instruments supporting the thermal modernization of single-family buildings.

The dominant role in supporting low-emission investments from public sources is played by European funds (75% of all public funds - EUR 2.4 billion). It is worth noting that over 70% of EU funds (EUR 2 billion) were used in 2014-2019 by the public sector at the national, regional and local level. In 2015-2018, the value of European funds exceeded national public funding over five times. Since 2016, the share of EU funds in the financing structure has been systematically decreasing, which was a direct result of the timing of competitions under the 2014-2020 financial perspective.

In this period, however, the declining share of European funds was not compensated by the increase in financing from domestic sources. In 2019, this picture changed significantly with a significant increase in the share of financing from the central budget (thermomodernization relief) and the National Fund for Environmental Protection and Water Management (the "Clean Air" program) in the structure of financing the renovation of buildings in Poland.

The model of financing low-emission investments in buildings by households (including both natural persons, communities and housing cooperatives) shows that this group of investors primarily made investments using capital from commercial banks and own funds. The remaining financing was obtained from the central budget (through the TRF and thermomodernization relief) and from the National Fund for Environmental Protection and Water Management.

Only 7% of investments made by this group of investors used EU funds. Investments implemented by enterprises were co-financed mostly by EU funds with a high intensity of support. The remaining financing was obtained on commercial terms from banks or covered by own contribution.

According to the estimates of experts from the Building Performance Institute Europe, annual energy savings thanks to thermal modernization alone may reach 26% of 2013 consumption by 2030, while the total net social benefits by 2045 may amount to around 170 billion euro (Energy Efficiency, 2018). Energy efficiency, low-carbon economy, and renewable energy sources would reduce emissions by 48-58% by 2030 and by 80-95% by 2050 (Staniszek and Zaborowski, 2014; Gielen *et al.*, 2019). One cannot forget here about other types of benefits, the synergistic effects of which are multiplied (Table 4).

Table 4. *Estimation of total benefits from thermal modernization of buildings*

Benefit	Multiplier
Save energy costs	1,0
Economic stimulus	1,5
Social benefits (health)	1,0
Environmental benefits	0,1
Benefits for energy networks	1,0
Total	4,6

Source: *Own work based on Staniszek and Zaborowski, 2014.*

As a result of the overlapping of various benefits, it can be concluded that the final value of the benefits is higher than the sum of the effects achieved in individual areas. According to BPIE experts, to estimate the total benefit for society resulting from renovation, modernization and thermal modernization of buildings, several multipliers of different values should be used, which ultimately reach EUR 157 billion (Staniszek and Zaborowski, 2014).

5. Summary and Recommendations

In EU countries, policies, incentives, climate change goals and corporate image result in a more efficient approach to energy use in buildings. The funds allocated for this purpose also serve this purpose. Introduced codes and practices regarding energy regulations for buildings include, inter alia, energy audit commitments, building certification requirements with energy efficiency assessment, carbon reduction targets for buildings, energy consumption charges. These activities are especially justified in the case of residential buildings, which are among the goods that meet basic human needs.

In Poland, subsidies are still the preferred method of providing financial support. They can cover up to 85% of the cost and therefore can reduce the incentives to develop and adopt innovative financial instruments. Financial instruments such as guarantees and ESCOs (only 23 companies in operation) are considered risky due to economic and political instability. What is more, there is a lack of experience and specialist knowledge in the field of creating more complex financial programs.

European funds play a dominant role in supporting investments in the field of energy renovation from public sources. In 2015-2018, the value of European funds exceeded national public funding over five times. Over 70% of EU funds have been allocated to building investments in the public sector at national, regional and local levels. The remaining value was gained by institutional entities managing multi-apartment buildings (housing cooperatives, housing communities, social housing associations).

Poland has committed to spend more than EUR 5 per square meter on the energy efficiency of public buildings and EUR 2 per square meter on the energy efficiency of residential multifamily buildings. No funds have been committed to energy efficiency in residential single-family houses. Moreover, the average cost per building, of deep renovation of public buildings is around 4 times higher than those for the renovation of multi-family buildings and over 23 times higher than in case of single family buildings.

Public buildings have a larger area and they are usually equipped with additional systems like cooling or mechanical ventilation. This means there is less administrative burden, since it requires dealing with fewer buildings for a given spend. Institutions implementing the EU programs do not like to deal with private investors (individual home owners) or small projects, such as the renovation of single family buildings. They prefer to spend money quickly and with fewer administrative formalities (Firląg *et al.*, 2020).

The established national financing programs are assessed as insufficient. It should be noted that the owners of single-family houses constitute the overwhelming majority (80%) of the ownership structure of apartments in Poland. However, they are not a homogeneous group. A dispersed group of owners is a barrier to systemic reaching with an offer of financial support. When preparing a program for the modernization of single-family houses, the key issue is to precisely define the addressees of the program. For each target subgroup, the legal instruments, financial instruments and institutional structure should be different. Therefore, the following recommendations are proposed:

- Eliminating information barriers on the benefits of thermal modernization and possible support instruments. Educational campaigns to save energy, water and heat in a building reach only some households.
- Activation of local governments to effectively reach the poorest households, often older people, digitally and communicatively excluded from full participation in local life.
- The main differentiating factors that may be helpful in the preparation of support programs are urbanization and the level of income. 90% of the inhabitants of rural areas live in single-family houses, while more than 60% of the income and energy poor are also rural residents. Expenditure on heating more than twice as much as expenditure on electricity in household

budgets. Considering the low efficiency of single-family houses, households living in them can relatively quickly be included in the group of energy poor. Therefore, the support should focus on preventing energy poverty, which is to a small extent implemented in Poland with the help of the paid energy supplement to cover part of the costs of energy purchase.

- The main instruments for wealthier people should be tax breaks offered in a wider range. So far, the tax relief introduced in 2019 enjoys great interest. 80% of the supported investments this year fell on the owners of single-family houses. This direction should be developed by supplementing it with an attractive credit product and other instruments.
- In addition, it is proposed to use the funds from the European emissions trading system, which Poland can count on in the next dozen or so years. However, it is necessary to change the approach, which currently focuses primarily on investment needs in the energy sector (Śniegocki, 2017).
- Part of the subsidies from TRF should be transferred to the Subsidy Fund supporting the development of social housing, the shortage of which (compared to other EU countries) is constantly observed. Increasing the public stock of rental housing would reduce the phenomenon of contradictory incentives.
- Regional air pollution due to low emissions should also be taken into account.

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